Update on Metacalibration for Weak Lensing Shear Measurement

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Outline

- Metacalibration
- Selection Effects
- ~~Additive Bias correction~~ I improvied this by a factor of 10, but cut from this talk for sake of brevity.

Shear Accuracy Requirements

- In order to measure the Dark Energy equation of state to the desired accuracy for DES/LSST, we must measure shear with exquisite accuracy.

$$\gamma = (1 + m) \times \gamma_{true} + c$$

- LSST Requirements
  - Multiplicative errors: $m \lesssim 0.001$
  - Additive errors: $c \lesssim 0.0001$

Metacalibration Idea from Eric Huff

- Say we have a biased shear estimator e. Then we can write

$$e(\gamma) = e|_{\gamma=0} + \gamma \left.\frac{\partial e}{\partial \gamma}\right|_{\gamma=0} + \ldots \quad (1)$$

$$\approx e^{psf} R^{PSF} + \gamma R \quad (2)$$

- Use image manipulation to estimate the derivative of the estimator with respect to shear

$$R = \frac{e(+\Delta\gamma) - e(-\Delta\gamma)}{2\Delta\gamma}$$

  - Deconvolve the PSF
  - Shear the image by a small amount
  - Reconvolve by the PSF. Use a slightly larger PSF to suppress the noise amplification

Metacalibration Idea from Eric Huff

- Corrects for modeling biases
- Corrects for *ordinary* noise-related biases
- Works well at high shear.

Correlated Noise

- These convolutions and shears result in *correlated noise*
  Last talk I showed how to correct for this
- Since then I have put the last pieces together
  - Selection effects
  - Additive bias

Selection Effects

- Applying a selection to objects, for example on the signal-to-noise ratio S/N, can indirectly select the shapes of galaxies and result in a biased shear recover.
- For example, putting a threshold on S/N tends to select less elliptical galaxies.

Selection Effects

- The mean shape given selection can be written as

$$\langle e\rangle = \int S(e)\ P(e)\ e\ de, \tag{3}$$

where $P(e)$ is the probability distribution of ellipticities and $S(e)$ is the probability of selection.
- The response is then

$$\begin{aligned}\left.\frac{\partial\langle e\rangle}{\partial\gamma}\right|_{\gamma=0} &= \int \left.\frac{\partial S(e)P(e)e}{\partial\gamma}\right|_{\gamma=0} de \\ &= \int \left[S(e)\left.\frac{\partial P(e)e}{\partial\gamma}\right|_{\gamma=0} + eP(e)\left.\frac{\partial S(e)}{\partial\gamma}\right|_{\gamma=0}\right] de \end{aligned} \tag{4}$$

$$\tag{5}$$

The first term is the response R we derived before, with selections based on the unsheared object parameters. The second term is the response of the ellipticity to selections. We can approximate the derivative using a finite difference:

$$\left.\frac{\partial\langle e\rangle}{\partial\gamma}\right|_{\gamma=0} \approx \langle R\rangle + \int e\ P(e)\left[\frac{S^{+}-S^{-}}{\Delta\gamma}\right] de, \tag{6}$$

Selection Effects

- Continuing...

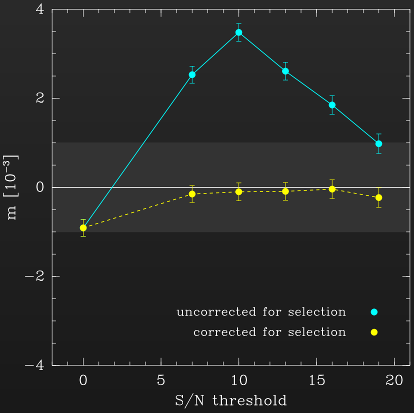
$$\left.\frac{\partial\langle e\rangle}{\partial\gamma}\right|_{\gamma=0} \approx \langle R\rangle + \int e\ P(e)\left[\frac{S^{+}-S^{-}}{\Delta\gamma}\right] de, \tag{7}$$

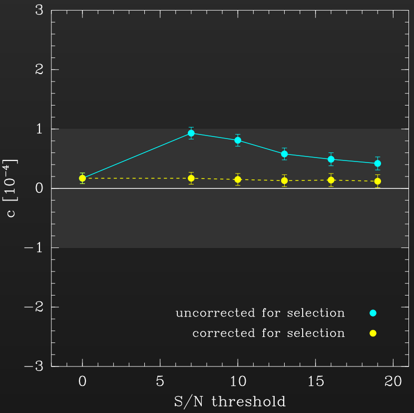
- We can thus rewrite this in terms of the mean ellipticity when selections are based on the sheared parameters:

$$\begin{aligned}\left.\frac{\partial\langle e\rangle}{\partial\gamma}\right|_{\gamma=0} &\approx \langle R\rangle + \frac{\langle e\rangle^{S+} - \langle e\rangle^{S-}}{\Delta\gamma} \\ &\equiv \langle R\rangle + \langle R_S\rangle, \end{aligned} \tag{8}$$

S/N thresholds

Select objects with S/N greater than some threshold.





S/N ranges

Select objects with S/N within some range. Split into 3 equal number bins